EGU25-11069

Open Session on the Magnetosphere: Tue, 29 Apr, 10:45-12:30

Amplitudes of Magnetopause Surface Waves: Comparison of THEMIS Observations with MHD Theory

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1. Motivation

- Earth's **magnetopause** (MP) in constant dynamic motion: e.g. solar wind variations and structures or velocity shear between magnetosheath and magnetosphere
  → **Waves** on MP (e.g. Plaschke et al., 2009; Archer et al., 2024)

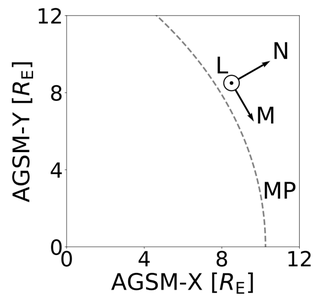
- Surface waves can be described by superposition of two evanescent waves – one on either side of MP
- According to magnetohydrodynamic (**MHD**) theory, **amplitude** ζ should **decrease exponentially** with distance x normal to the MP (e.g. Plaschke & Glassmeier, 2011; Plaschke, 2016):

$$\zeta(x)=\zeta_0 e^{ik_N x}$$

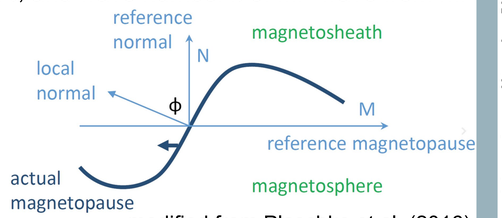
- **Comparison** of **S/C observations** with MHD **theory**

2. Methods & Data

- Magnetic field B and ion velocity V_i from **THEMIS** mission
- LMN - coordinate system with model MP (Shue et al., 1998)



- Phase velocity V_{ph}, period τ, and wave number k of MP wave from MP crossing (MPC) of S/C:
  - Minimum Variance Analysis (MVA) for local normal and wave propagation direction
  - Consecutive MPCs for τ
  - V_{ph} approximated with V_i



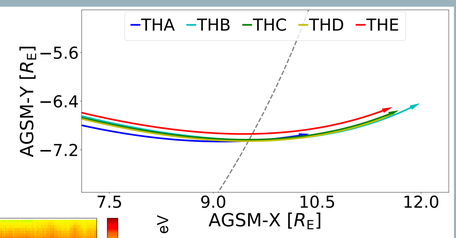
modified from Plaschke et al. (2016)

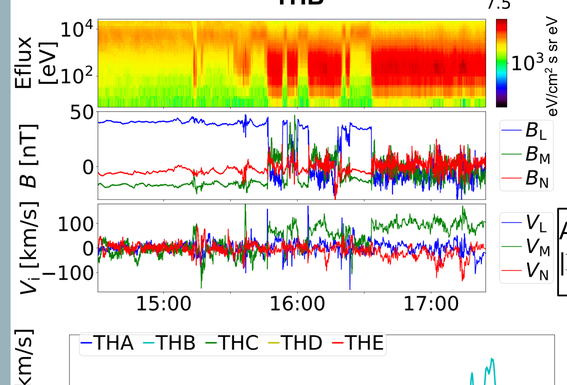
Data Processing:

- **Shift data** from different S/C according to cross correlation
- Apply 60s **smoothing**
- Calculate analytic signal to get **amplitude**
- Calculate **distance** between S/C **in N-direction**

3. Case I

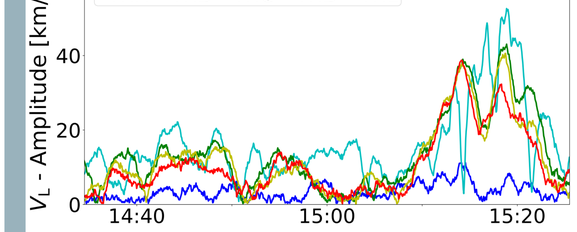
- Event on 2007-08-23
- all S/C observe **low frequency oscillations** in V_i and B

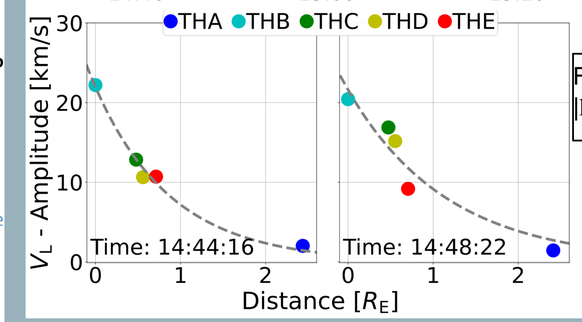




- Multiple MPCs at THB (V_{mp}= 67±23 km/s)

Analysis of **MPCs**: $|k_N|$= (1.57±0.93)10^{-4} 1/km



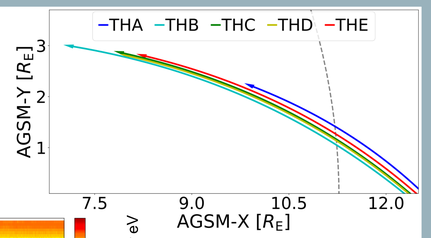


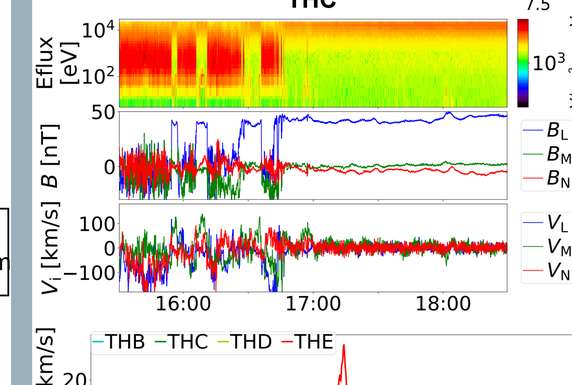
Fit to **data**: $|k_N|$= (1.16±0.26)10^{-4} 1/km

Consistent?

4. Case II

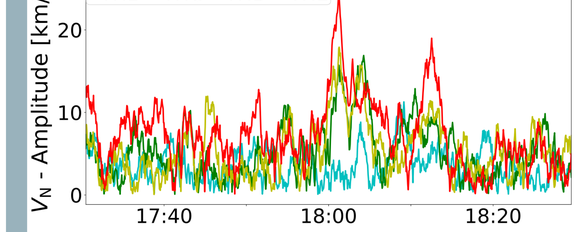
- Event on 2007-08-08
- all S/C observe **low frequency oscillations** in V_i and B

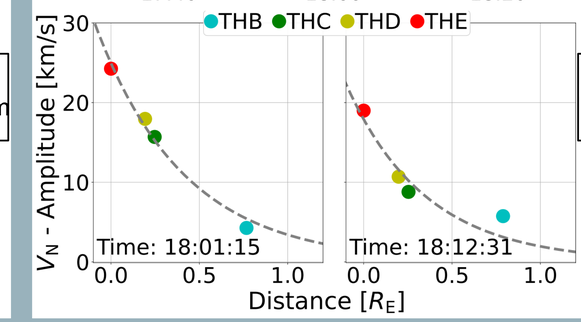




- Multiple MPCs at THA (simultaneous to waves at THB-THE) (V_{mp}= 122±114 km/s)

Analysis of **MPCs**: $|k_N|$= (5.08±5.61)10^{-5} 1/km





Fit to **data**: $|k_N|$= (3.30±0.72)10^{-4} 1/km

Discrepancy?

5. Summary & Outlook

Comparison of observation and theory:
1) Case: agreement
2) Case: disagreement

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Possible reasons:
- Properties of MP wave not good enough determined
- MHD Theory only limited applicable
- Other sources of waves

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What's next?
- Expand case study to statistical study with further multi-spacecraft observations
- String-of-Pearl Configuration:
  1) THEMIS (Coast Phase ~ 70 Events)
  2) MMS (current campaign)

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References:

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Acknowledgments:

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